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Water absorption as an evaluation method of cooking quality for yam (*Dioscorea alata*) and cassava (*Manihot esculenta crantz*)

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Abstract

Water absorption as a new method of cooking quality (hard cooking or mealy cooking) of yam and cassava cultivars determination was studied by cooking eight (08) cultivars. 30 g of each were boiled in 500 ml of water during 20 minutes and dried at 70°C for 15 hours and 103°C for 3 hours in a vacuum oven. Results showed that cassava and yam have different cooking quality. Dry matter content does not influence the cooking quality of yam and cassava. Mealy cooking quality of yam absorbs less water (6.6%) during cooking but looses more soluble dry matter (9.5%) during the same process. Hard cooking quality of yam absorbs much water (23.5%), but looses less soluble dry matter (3.9%). The soluble dry matter is the main parameter to determine the quality of *D. alata*. It stands at 9.5% ± 2.9 for mealy cooking quality and 3.9 ± 0.73 for hard cooking quality cultivars of *D. alata*. Water absorbed by mealy cooking cassava (27.6%) is significantly ($p < 0.05$) higher compared to water absorbed of hard cooking cassava (12.4%). Water absorbed during cooking is the main parameter in determining the quality of cassava cultivars. Water absorbed stands at 27.6% ± 8.8 for mealy cooked quality and 12.4% ± 1.9, for hard cooked quality of cassava cultivars. A close relation between water absorption and cooking quality was revealed to contribute to a better selection procedure for cultivars in the frame of food security.

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Keywords: yam; cassava; water absorption; mealy cooking; hard cooking

1. Introduction

Yam and cassava are tropical crops which are used as energy-rich staple foods mainly in West Africa [1, 2] and contribute to food security. In Côte d'Ivoire, yam is the first food crop with 6,932,950 tons per

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year, followed by cassava with 2,951,160 tons per year [3]. *D. alata* being the mostly cultivated species with a large number of varieties [4]. Yam and cassava production also contribute to the food diversification of the increased urban populations. Thus, with the intent to face the increased food requirements of consumers and ensure food security, breeding programs with the selection of high-yield yam and cassava varieties have been initiated in many agronomic research stations in West Africa. Certain varieties showed enormous agronomic interests, however their hard cooking quality stays a limitation to their consumption. Boiled is one of the most common form of consumption of yam and cassava in Côte d'Ivoire and the main quality attributes of boiled yam and cassava required by consumers is the final texture [5] characterized by a high mealy cooking of varieties. Mealiness is the easiness of disintegration of the boiled yam [6]. The main quality attributes of boiled cassava are whiteness, sweetness and friability, all of which should be high [7]. Cooing quality is usually related to the cooking time. So in Brazil, a cassava variety is considered of good cooking quality when it cooks to a final, friable texture in less than 20 min [8]. Other authors have related potato friability to starch content or starch properties [9]. However, [10] concluded that mealy and firm textural of cassava varieties were very similar and the difference in cooked cassava root texture was not attributable to the molecular structure of starch. But starch swells during boiling, inducing a distension of the cell wall which facilitates cell separation in mealy potatoes [9]. This indication can be the main way to understand yam and cassava cooking quality since no relationship between cooking quality and water absorption during cooking process has been yet established.

The objective of this study was to perform a new method of yam and cassava cooking quality evaluation and access the most important parameter enabling to differentiate between mealy cooking and hard cooking cultivars.

2. Materials & Methods

2. 1. Material

Eight cooking cultivars of cassava (*Manihot esculenta crantz)* and yam (*D. alata)* have been collected at the agronomic research stations in Bringakro and Adiopodoumé in Côte d'Ivoire. Two mealy cooking cultivars of cassava (Bonoua2 and A12F) and yam *D. alata* (IB88 and 886); two hard cooking cultivars of cassava (Yacé and KA13) and two hard cooking cultivars of yam (95/00010 and 01/00074) have been selected. Cassava was collected at 12 and 18 months after planting, while yam was harvested after 7 months**.**

2. 2. Cooking quality parameters

Cooking was carried out as described by [11] with a modification by cutting off 1/10 cm of both distal and proximal ends. The rest of the varieties were cut into small pieces of 10 mm^3. 30 g of these pieces were weighed per sample and cooked in 500 ml of boiling water for 20 minutes. The cooked pieces were collected in a 1 mm mesh sieve and immersed 10 times in cold water and allowed to stand for 2 minutes. The last drops under the sieve were removed with a blotting paper. For dry matter determination, 30 g of the fresh sample were weighted. Cooked and fresh pieces were dried at 70°C for 15 hours and then at 103°C for 3 hours in a vacuum oven (Chopin vacuum dry oven, M. Chopin & Co., F-Boulogne). The cooking quality parameters (dry matter, water absorbed during cooking, soluble dry matter during cooking and water absorption capacity) were calculated per 100 g of raw matter.

2. 3. Statistical analyses

All determinations reported in this study were carried out in triplicates. Mean value and standard deviation were calculated. Analysis of variance (ANOVA) and correlations were also performed. Tukey's (HSD) test at $P < 0.05$ was used for mean values separation.

3. Results & Discussion

3. 1. Cooking quality parameters of yam cultivars

The cooking quality parameters of yam cultivars are provided in Table 1. The dry matter content of mealy cooking cultivars (25.4 %) and hard cooking cultivars (23.3%) are not significantly different ($p \leq 0.05$). However within each quality cooking group, cultivars were observed to have significantly different dry matter content. The results then showed that the dry matter content depend on the cultivars, but it contribution to yam cooking quality determination was not establish, in contrary to many authors [12]; [13] [14]; who mentioned that potato dry matter is an important indicator of quality evaluation . The mealy cooking yam absorbs significantly ($p < 0.05$) less water during cooking (6.6%) compared to hard cooking yam (23.5%). However, mealy cooking yam has significantly ($p < 0.05$) more soluble dry matter (9.5%) than hard cooking yam (3.9%). The yam cooking parameter (Fig 1) indicated that mealy cooking cultivars absorb less water with high soluble dry matter but hard cooking cultivars absorb more water and show few soluble dry matter. The high positive correlation ($r = 0.84$; $p < 0.05$) observed between soluble dry matter and mealy cooking yam and the negative correlation ($r = -0.84$; $p < 0.05$) with hard cooking yam (Table 3) are essentially establishing a strong correlation as well as providing valuable information on the main parameter of yam cooking quality. This can be explain by a more pronounced detachment of cells of *D. alata* cultivars [15] as the lower soluble dry matter of hard cooking cultivars could be due to a high structural rigidity of the swollen granules and/or to an increased aggregation rate of amylose [16]. The negative correlation ($r = -0.62$; $p < 0.05$) between water absorbed and soluble dry matter reveals that these two quality parameters are opposite concerning yam. The microstructure of mealy boiled yam showed clear soluble of the typical reticular microscopic structure, cell wall distension and complete cell separation but in the waxy (hard) varieties microstructure, showed no cell separation [17]. These phenomena may explain the high soluble dry matter of mealy cooking yam ranging from 6.9 to 12.1% and the significantly lower soluble dry matter of hard cooking yam ranging from 6.3 to 6.9%.

Table 1. Cooking quality parameters of yam cultivars

Quality reference	Cultivars	Dry matter (%)	Water absorbed (%)	Soluble dry matter (%)	Water absorption capacity (%)
Yam mealy cooking	IB88	27.9^{a}	6.3^{c}	12.1^{a}	8.8^{c}
	886	23.0^{b}	6.9^{c}	6.9^{b}	8.9^{c}
	Mean value	25.4^{a}	6.6^{b}	9.5^{a}	8.8^{b}
Yam hard coking	95/00010	17.2^{c}	12.8^{b}	3.8^{c}	15.5^{b}
	01/00074	29.4^{a}	34.2^{a}	4.0^{c}	48.4^{a}
	Mean value	23.3^{a}	23.5^{a}	3.9^{b}	32.0^{a}

Each result of cultivars parameters are mean values of triplicate determinations. Mean value within the same column having the same letter are not significantly different at Tukey; $p < 0.05$

3. 2. Cooking quality parameters of cassava cultivars

The cooking quality parameters of cassava cultivars are presented in Table 2. The results revealed that dry matter content decreased with cultivars age (12-18 months) for all cultivars, except for Yacé. The water absorbed during cooking and the soluble dry matter of mealy cooking cassava were observed to decrease with cultivars age (12-18 months) whereas the water absorbed and the soluble dry matter of hard cooking cassava increase with cultivars age (12-18 months). It was observed a great variation in the dry matter content of mealy cooking cultivars, ranging from 37.9 % to 42.5% and also for the dry matter of hard cooking cultivars ranging from 38.9% to 45.1%, without any significant difference ($p < 0.05$) between mealy cooking and hard cooking cultivars. The dry matter content does not influence cassava cooking quality. Similar result was observed by [7] when taking into consideration the water content instead of the dry matter. As shown in Table 2, water absorbed of mealy cooking cassava (27.6%) is significantly higher ($p < 0.05$) compared to water absorbed of hard cooking cassava (12.4%) and mealy cooking cassava has significantly ($p < 0.05$) more soluble dry matter (5.8%) than hard cooking cassava (3.2%). Soluble dry matter of cassava, allowed to access cassava cooking quality. Moreover, the high correlation ($r = 0.79$; $p < 0.05$) as mentioned in Table 3, between water absorbed and mealy cooking quality, showed water absorbed during cooking as the main parameter at determining the cooking quality of cassava cultivars. When the water absorbed reaches (27.6% ± 8.84), cultivars are mealy cooked and present friable texture. Calculated on water content of fresh roots basis, water absorbed capacity indicated cell wall behavior of cultivars probably due to starch swelling activity during hydrothermal treatment. Friability of cooked cassava appeared to be related to starch functional properties [18]. The study clearly established that, mealy cooking cassava can absorb till 46.7% of its own water content of fresh roots, while hard cooking cassava water absorption capacity, is two less times lower (21.2%). Unlike of mealy cooking, hard cooking cassava absorbs at least 12.4% ± 1.92 of water during cooking and gives hard and glassy cooked texture. The cassava cooking parameter progress (Fig 2) indicated that mealy cooking cultivars absorb more water and loose also more soluble dry matter and displayed a strong water absorption capacity particularly at 12 months age. The hard cooking cultivars absorb less water and show lower water absorption capacity (21.2%). The high water absorption capacity may be due to amylopectin activity, since amylopectin is primarily responsible for starch granule swelling [19, 20].

Table 2. Cooking quality parameters of cassava cultivars

Quality references	Cultivars	Dry matter (%)	Water absorbed (%)	Soluble dry matter (%)	Water absorption capacity (%)
Cassava mealy cooking	Bonoua2 12	42.5^{b}	33.3^{b}	8.1^{a}	57.9^{b}
	Bonoua2 18	40.6^{bc}	19.5^{c}	3.0^{b}	32.8^{c}
	A12F 12	41.2^{b}	38.0^{a}	6.8^{a}	64.6^{a}
	A12F 18	37.9^{d}	19.5^{c}	2.7^{b}	31.4^{c}
	Mean value	40.5^{a}	27.6^{a}	5.8^{a}	46.7^{a}
Cassava hard cooking	Yacé 12	40.4^{bc}	9.4^{e}	2.9^{b}	15.7^{e}
	Yacé 18	45.1^{a}	13.2^{d}	3.5^{b}	24.0^{d}
	KA13 12	40.9^{bc}	13.1^{d}	3.0^{b}	22.2^{d}
	KA13 18	38.9^{cd}	14.0^{d}	3.4^{b}	22.9^{d}
	Mean value	41.3^{a}	12.4^{b}	3.2^{b}	21.2^{b}

*Number after cultivars names indicate harvest time after planting
*Each result of cooking parameters is mean value of triplicate determinations. Mean value within the same column having the same letter are not significantly different at Tukey; $p < 0.05$

Table 3. Correlation coefficients between yam and cassava cooking quality references and cooking quality parameters

	Yam cultivars				Cassava cultivars			
Cooking quality parameters	Mealy cooking	Hard cooking	Soluble dry matter (%)	Water absorbed (%)	Mealy cooking	Hard cooking	Soluble dry matter (%)	Water absorbed (%)
Soluble dry matter (%)	0.84	-0.84			0.60	- 0.60		
Water absorbed (%)	- 0.75	0.75	- 0.62		0.79	- 0.79	0.91	
Water absorption capacity (%)	- 0.70	0.70	- 0.58	1	0.77	- 0.77	0.92	1

Correlation is significant at $P < 0.05$.

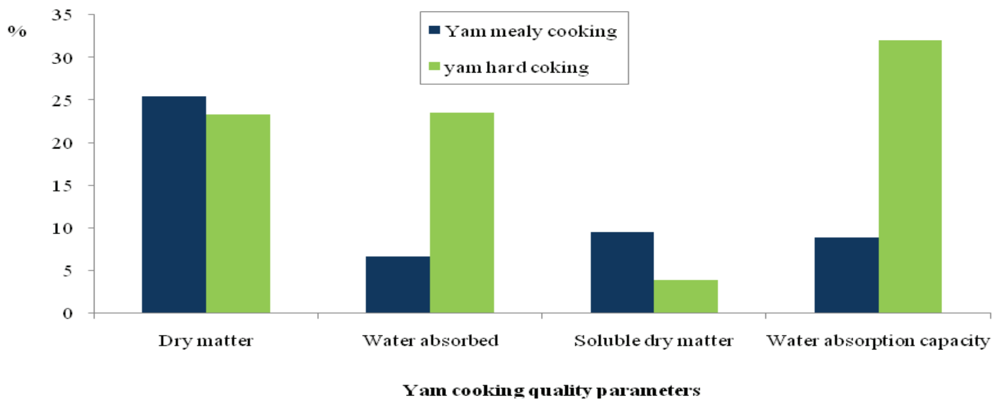

Fig. 1. Yam cooking parameter progress

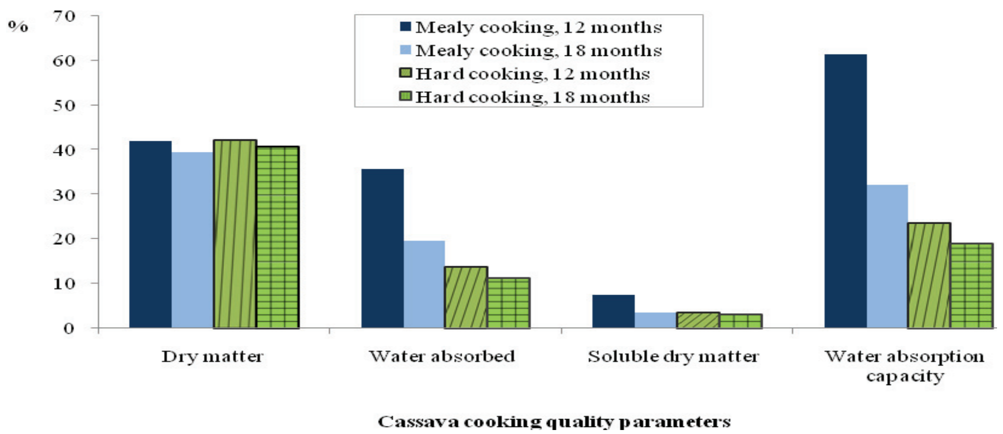

Fig 2. Cassava cooking parameter progress

4. Conclusion

The study reveals that yam and cassava have different cooking quality parameters. The level of water absorption was the main indicator of cooking quality of cassava cultivars and soluble dry matter provided more information on yam (*D. alata*) cooking quality determination. This new method brings an added value by promoting the establishment of cooking quality limits, which could contribute to a better selection procedure for cultivars in the frame of food security.

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